Neutrino energy reconstruction in the DUNE far detector

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Updates

Updates for ν_e CC events:

1. Found and fixed bug in code that sums hit charge in reco shower.

2. Further studies on bias in reconstructed ν_e energy as a function of true energy.

3. Look at ν_e energy resolution for different interaction modes.

Method

For ν_e CC events, use reco shower with highest total hit charge. These are emshower showers made from shower-like Pandora PFParticles (PDG code = 11). Estimate shower energy from sum of hit charges in the shower with lifetime correction and an average recombination correction of 1/0.63 applied. Add hadronic energy from sum of charges of hits not in shower with same corrections.

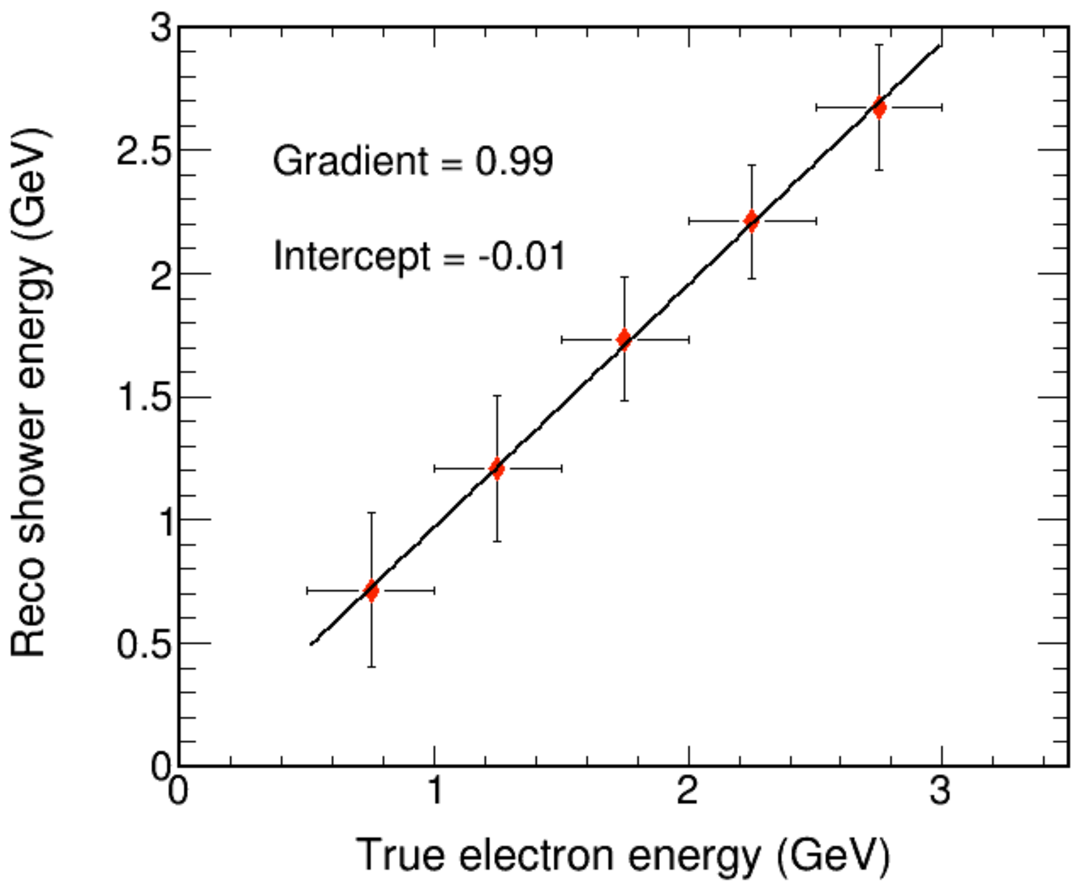
Results are from 20000 ν_e events in the 10 kt 1x2x6 geometry.

Define a fiducial volume as $|x|<=310$, $|y|<=550$, $50<=z<=1250$ cm, and include only events with true vertices within this fiducial volume.

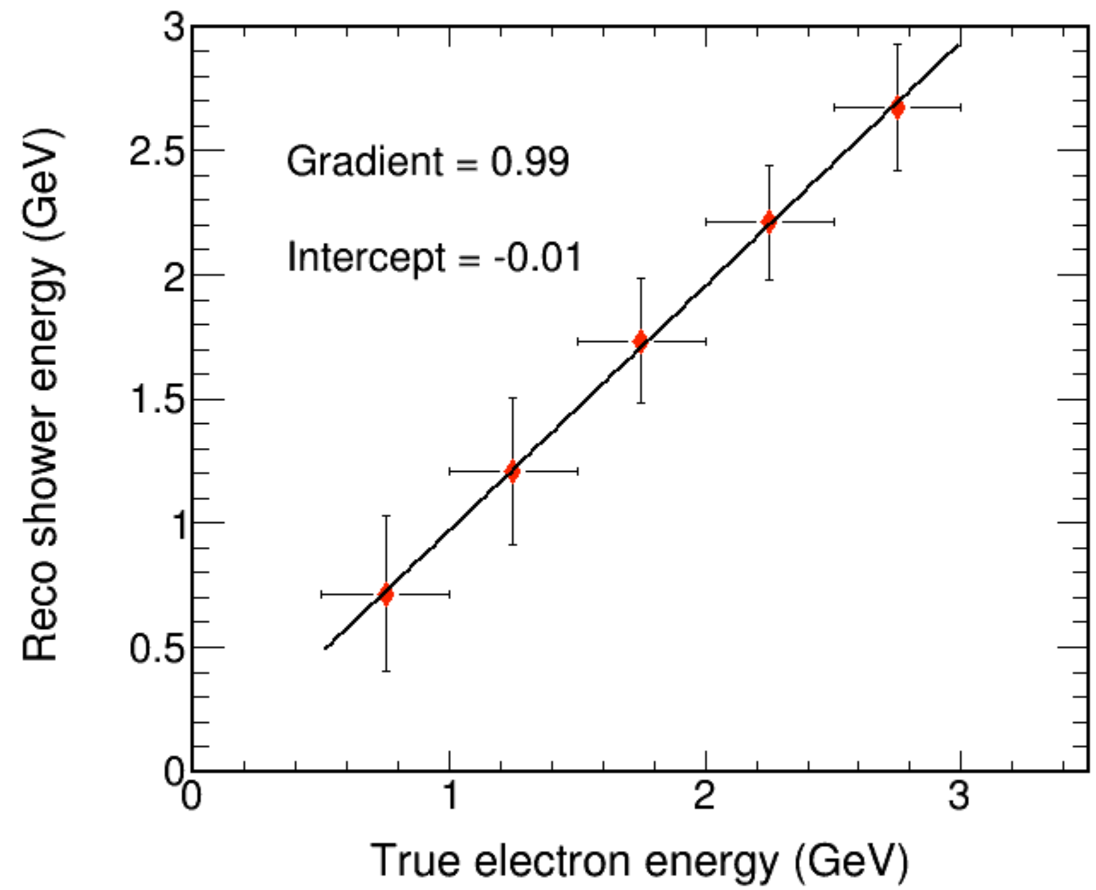
Correction of reco shower energy

On 9th January, I showed plots of correction of reco shower energy that were different depending on whether module labels were set to PMTrack or Pandora. These plots should be identical since emshower showers are used in both cases. These plots are after the bug fix.

Set VertexLabel, TrackLabel and CalModuleName to pmtrack



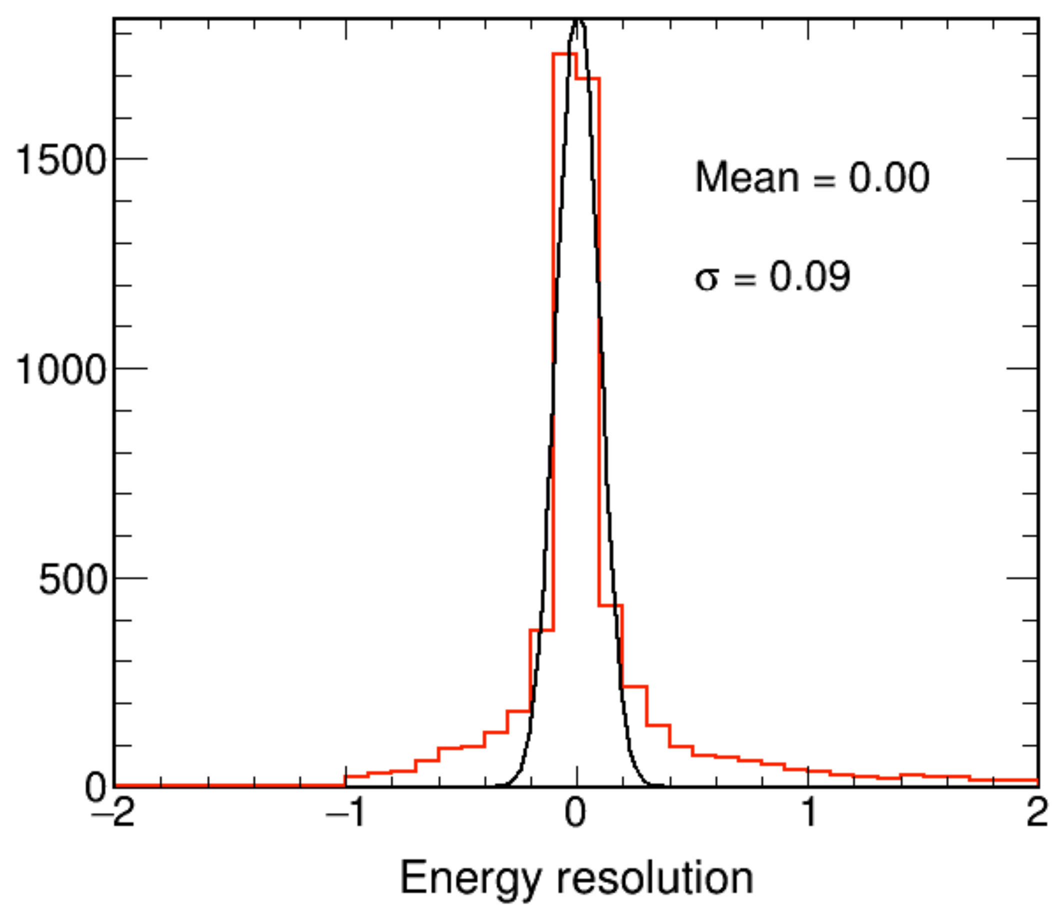
Set VertexLabel, TrackLabel and CalModuleName to pandora



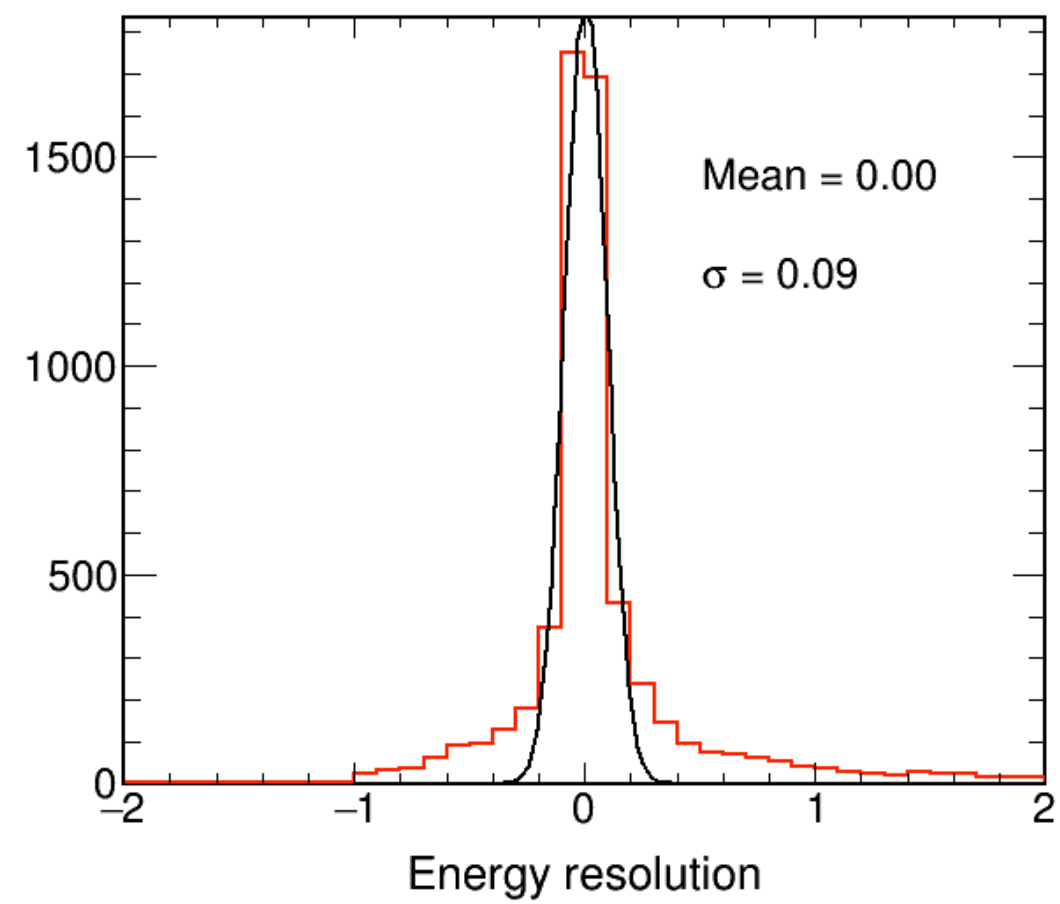
Reco shower energy resolution

True CC events
emshower showers

Set VertexLabel, TrackLabel and CalModuleName to pmtrack



Set VertexLabel, TrackLabel and CalModuleName to pandora



Bias in reco energy

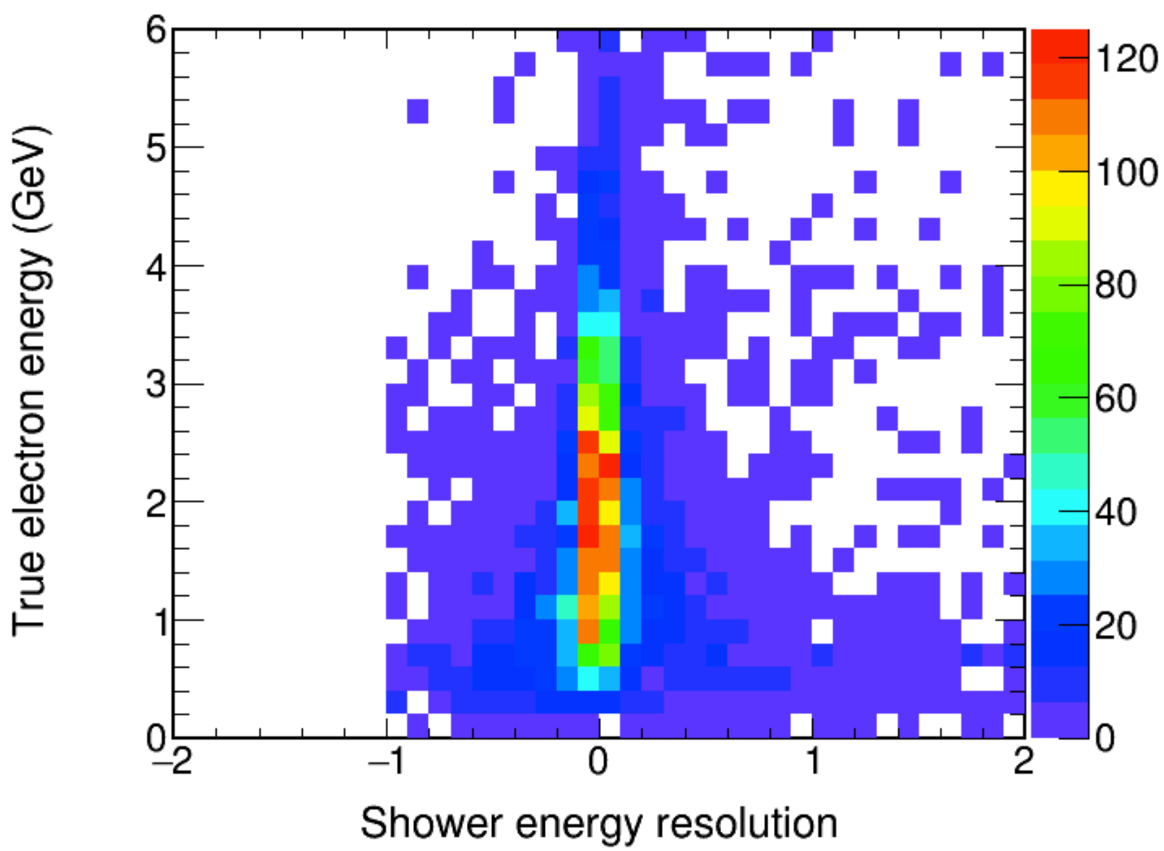
Changes to fits that make corrections of reco shower energy and hadronic energy:

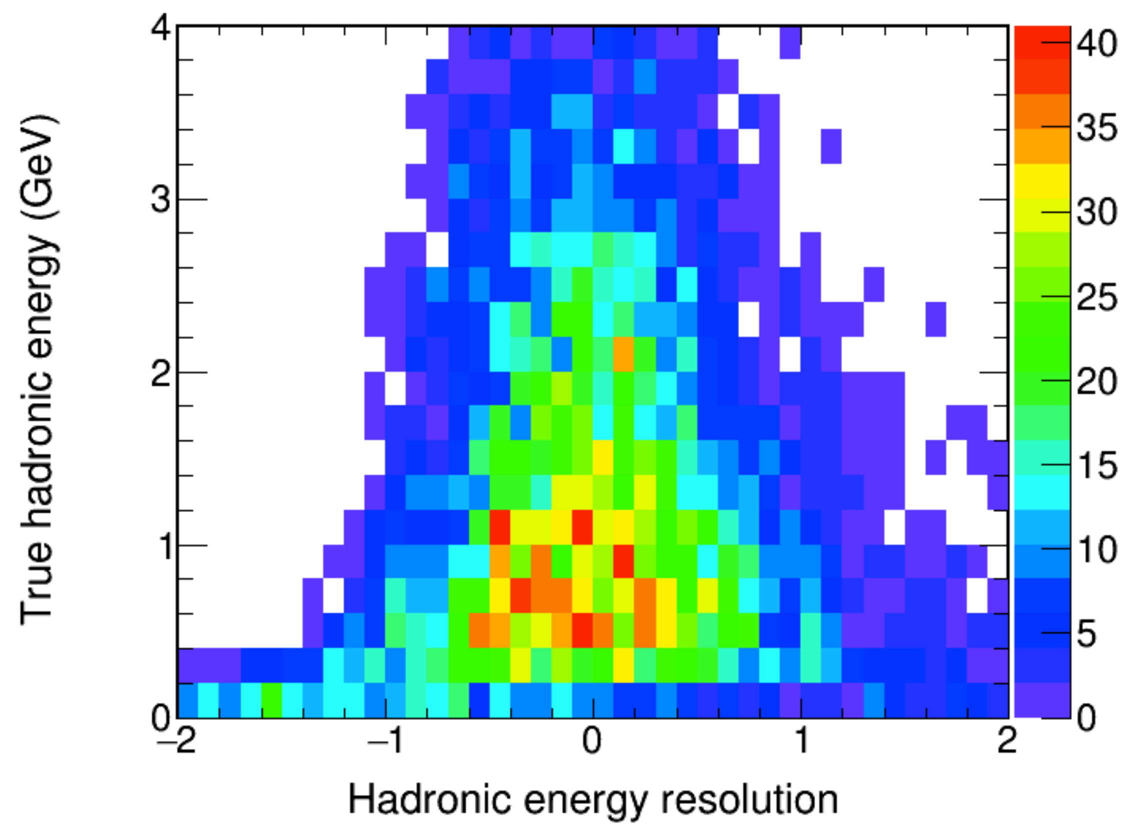
1. Make y error bars $\sigma/\sqrt{n}$ where σ is σ of Gaussian fit of that bin.
2. Ignore x errors.

Bias in reco energy

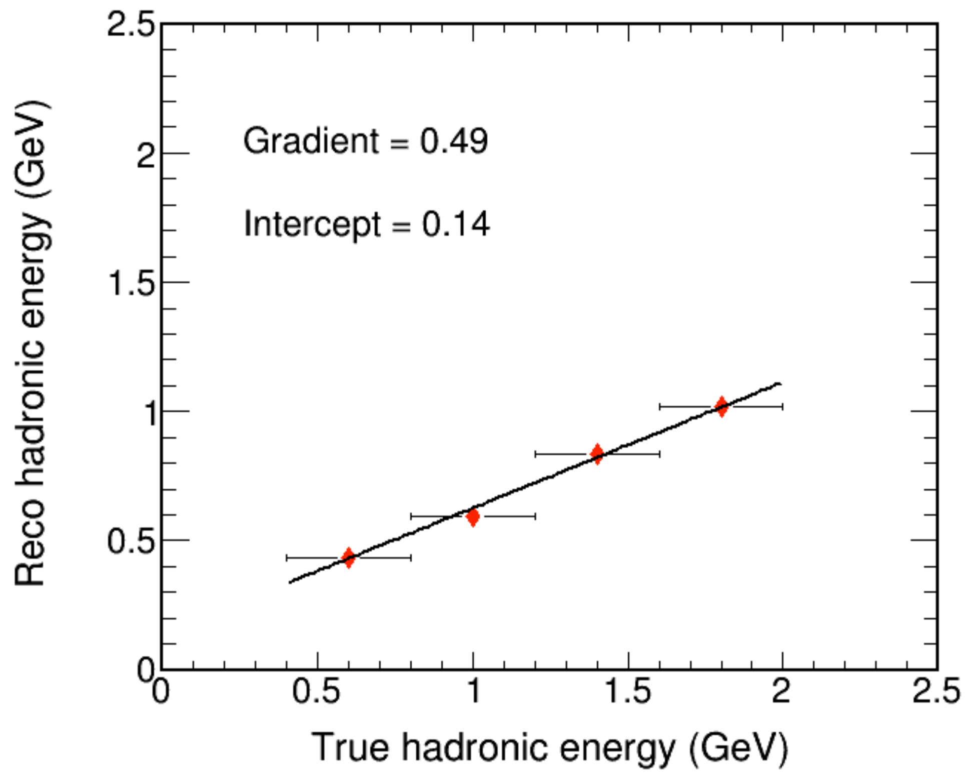
Plot shower energy resolution against true electron energy and hadronic energy resolution against true hadronic energy.

See clear negative bias in hadronic energy resolution at low true hadronic energy. (tail < -1 is due to subtraction of intercept of correction graph).

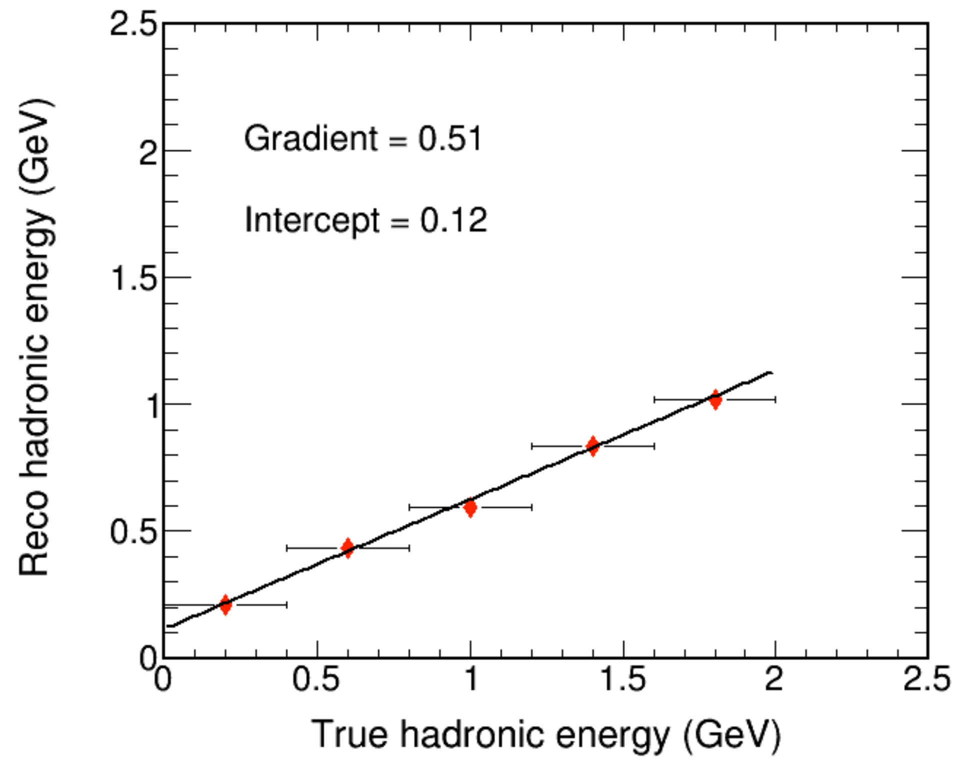




Bias in reco energy



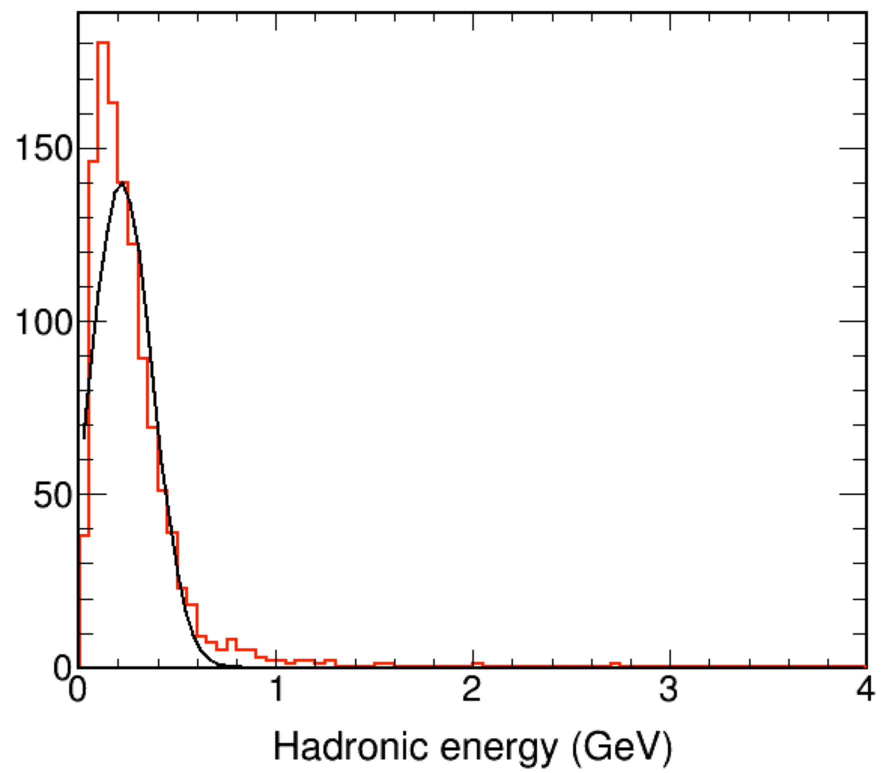
Have been using this graph to correct hadronic energy. It has 4 bins in true hadronic energy: 0.4-0.8, 0.8-1.2, 1.2-1.6,1.6-2.0 GeV



Add 5th bin from 0.0-0.4 GeV as reco energy bias is mainly at low energy.

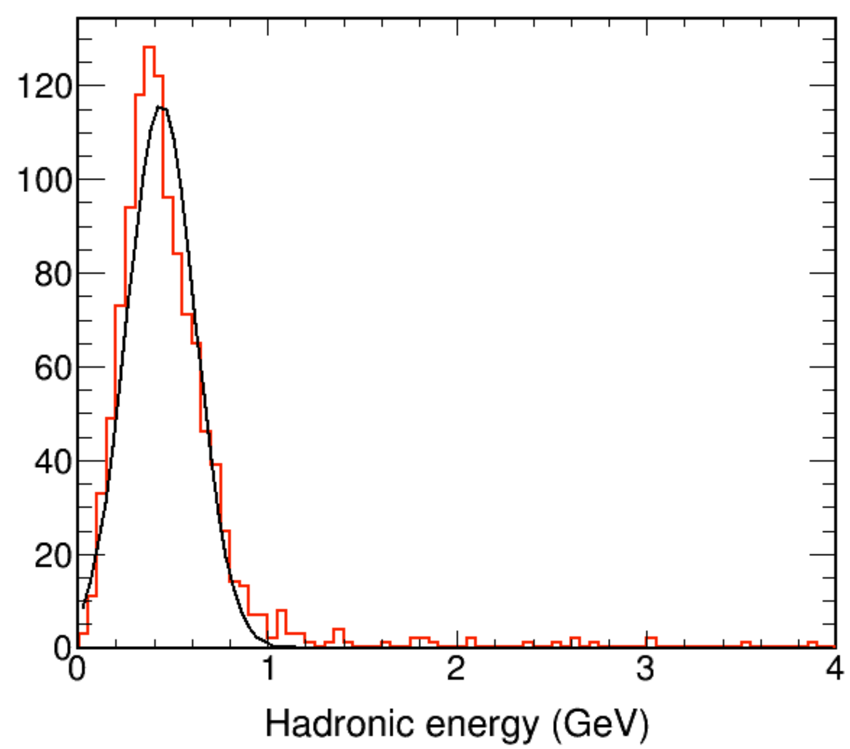
This gives small increase in gradient and small decrease in intercept.

Bias in reco energy



Reconstructed hadronic energy for true hadronic energy 0.0 - 0.4 GeV.

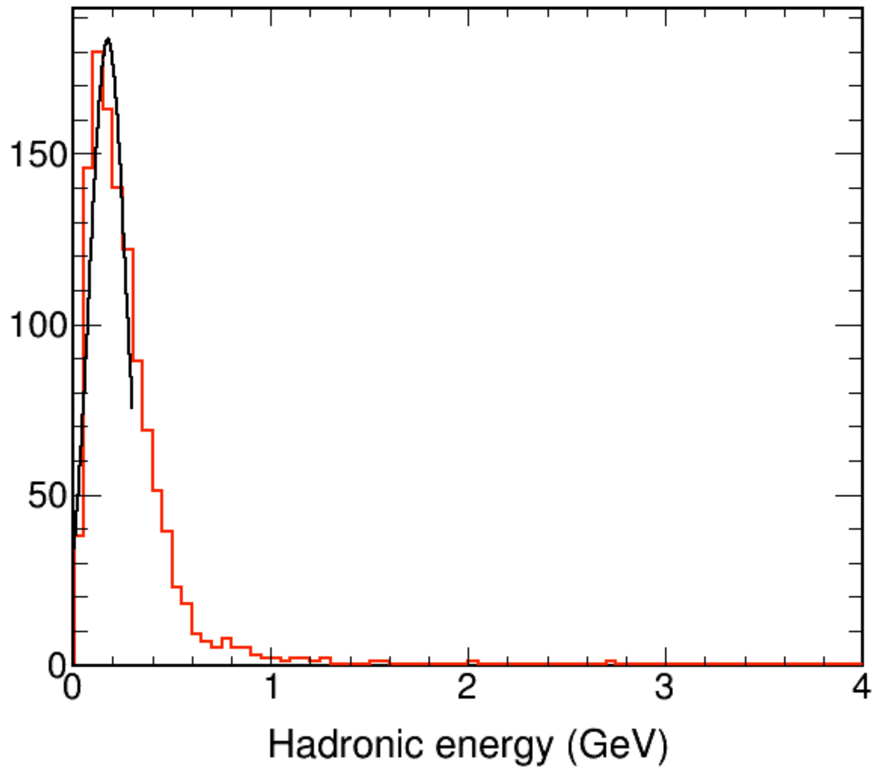
Fit mean is too high.



Reconstructed hadronic energy for true hadronic energy 0.4 - 0.8 GeV.

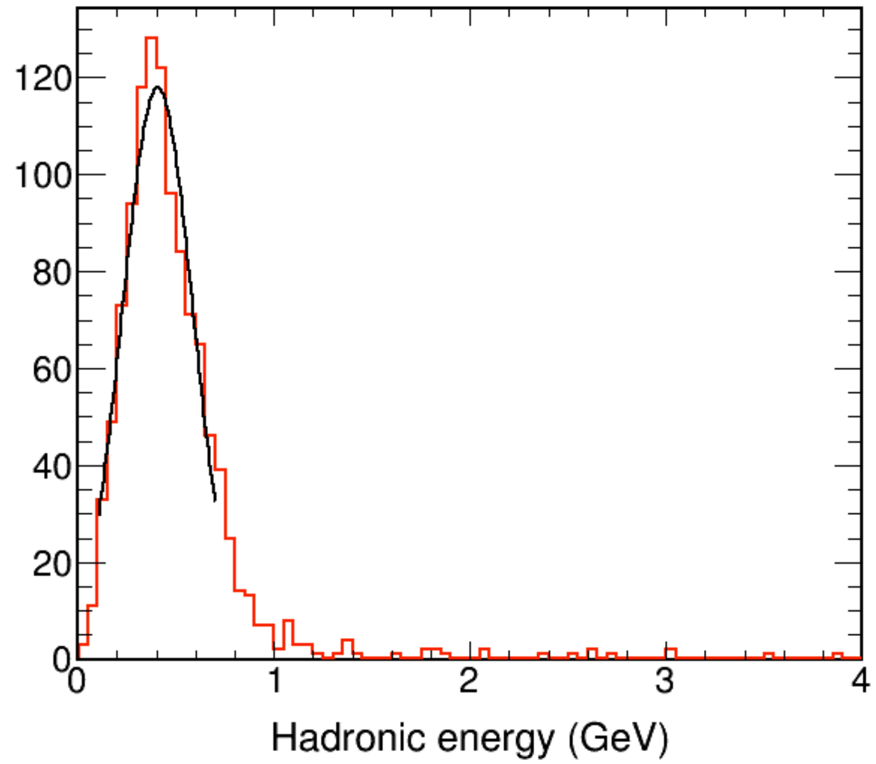
Fit mean is too high.

Bias in reco energy



Reconstructed hadronic energy for true hadronic energy 0.0 - 0.4 GeV.

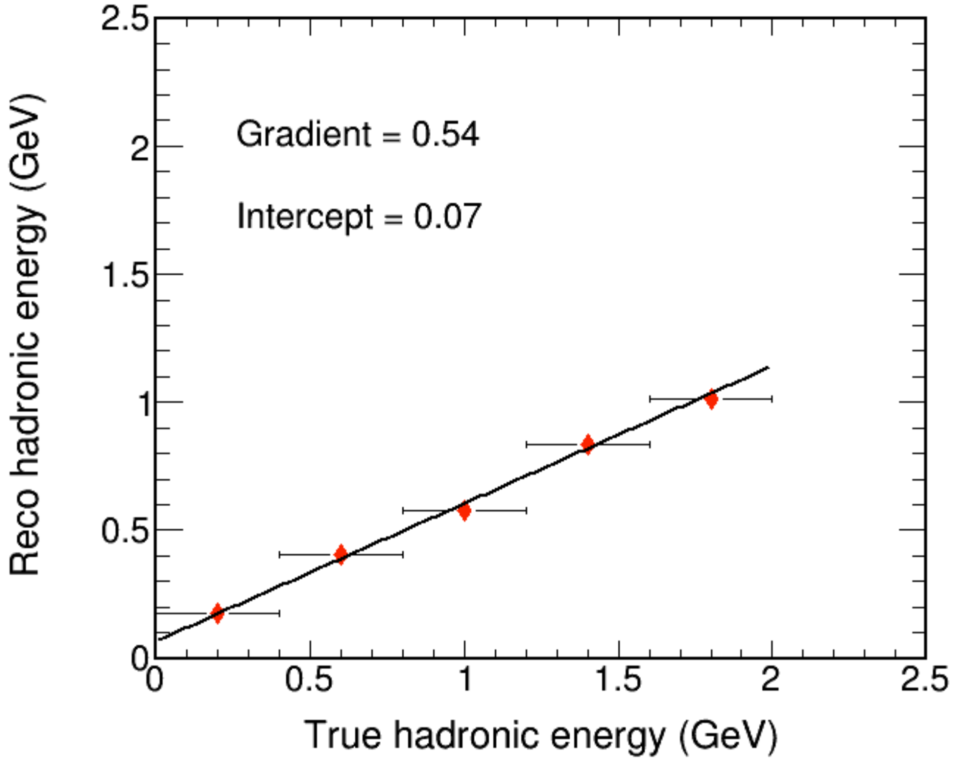
Change fit range, fit mean is better.

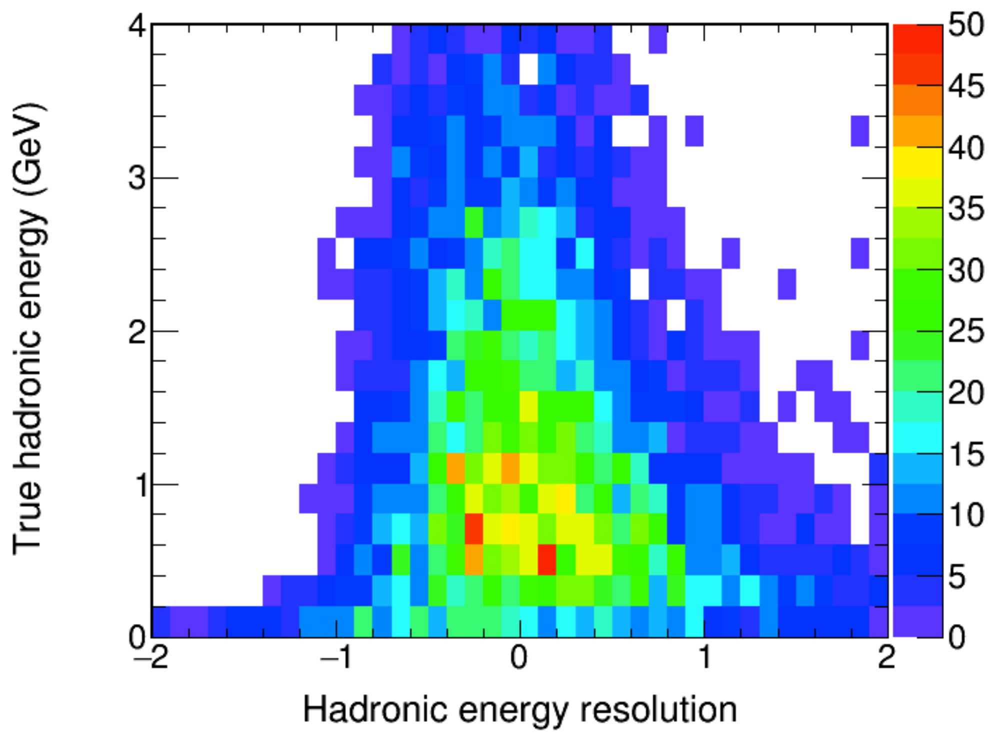


Reconstructed hadronic energy for true hadronic energy 0.4 - 0.8 GeV.

Change fit range, fit mean is better.

Bias in reco energy

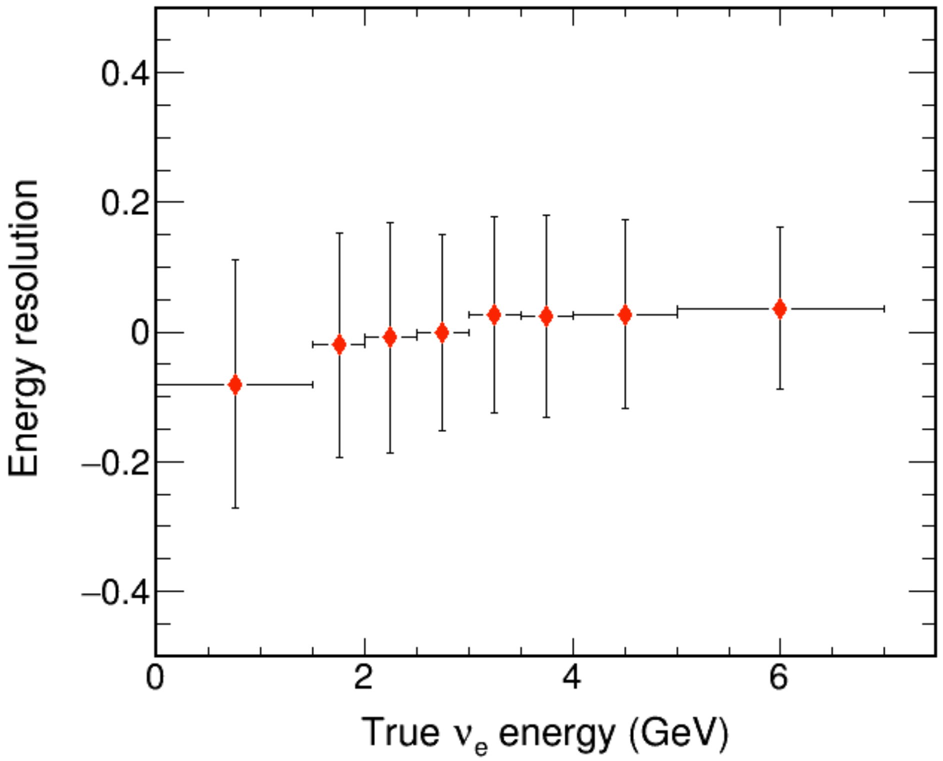




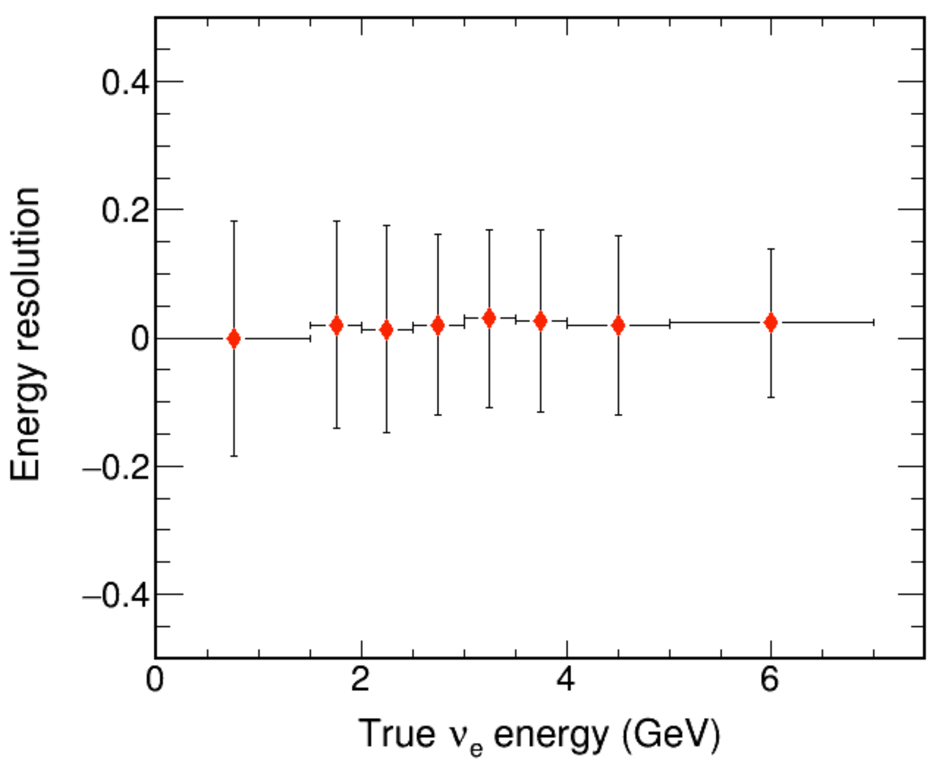
After changing fit ranges in two lowest energy bins, gradient has increased and intercept decreased slightly more.

Negative bias in hadronic energy resolution at low energy is reduced. This is at least partly due to reduction in value of intercept.

Bias in reco energy



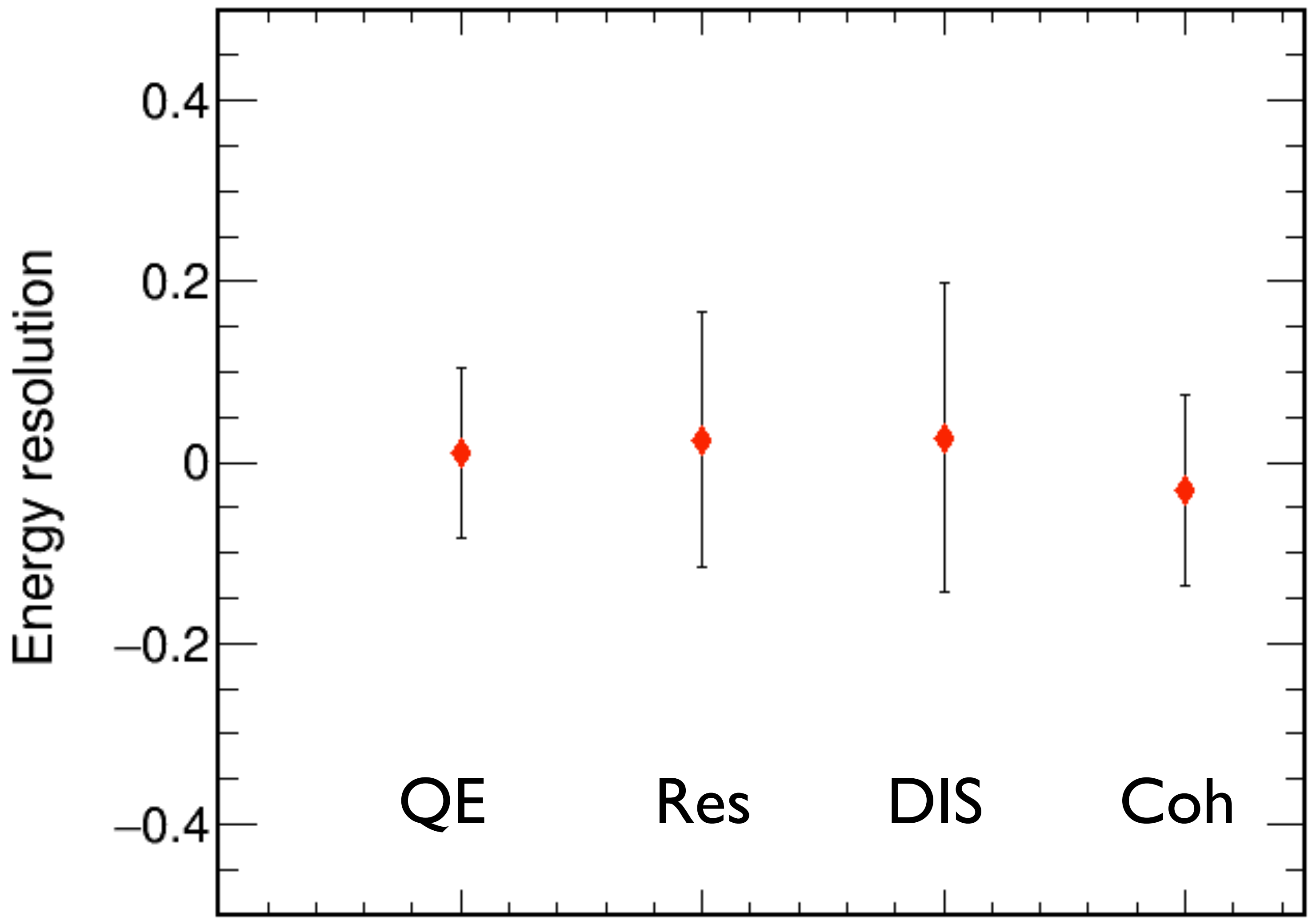
Before changes to correction of hadronic energy
(if corrected hadronic energy < 0, set it to 0).



After changes to correction of hadronic energy
(if corrected hadronic energy < 0, set it to 0 - this now happens less often as intercept is reduced).
Bias is reduced and σs of Gaussian fits are 1-2% smaller.

Energy resolution for different interaction modes

True CC events



BACKUP SLIDES

True ν_e energy and true electron energy

True CC events